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Handedness and its relationship to the retrieval of face-memory, under the conditions of elaborative and non-elaborative encoding

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As the effects of increased hemispheric interaction in handedness influencing episodic memory have been found in studies investigating the effects of handedness on memory, the intention of this study was to observe the effects of handedness and its relationship to the retrieval of face-memory. This evaluated whether or not handedness would have an effect/enhance the retrieval of episodic memory on tasks that demand deeper levels of processing, and high retrieval processes; in line with theoretical predictions by Christman and Butler (2011), a memory advantage for Mixed-Handers occurs due to Mixed-Handed subjects being able to engage in deeper levels of processing, due to superior interactions between the cerebral hemispheres. A 2x2 repeated measures experimental design was used, with the within subjects variables being performance on face-name recognition tasks under the conditions of elaborative and non-elaborative learning. The between subjects variable was the handedness groups (Strongly Right-Handed vs Mixed-Handed). Analysis of the data by 2x2 mixed ANOVA found a significant main effect for coding, within the elaborative coding condition. The findings do not support the hemispheric interaction theory, as no significant main effect was observed.

KEY WORDS:	**EPISODIC MEMORY**	**HANDEDNESS**	**INTERHEMISPHERIC INTERACTION**	**ELABORATIVE ENCODING**	**NON-ELABORATIVE ENCODING**

Introduction

An evolving frame of evidence is being studied, showing that the degree of handedness (inconsistent versus consistent) is a more fitting and robust approach of classifying handedness in comparison to the traditional way of using the direction approach (left versus right). Although previous research has assessed the effects of direction of hand preference on behaviour, more prominent evidence has demonstrated that the most critical dimension on which the handedness groups fluctuate is in degree of handedness preference. This may be a more appropriate indicator of cerebral organisation and behaviour. Thus we would argue that the most dominant reason to which previous research has failed to determine handedness effects on behaviour is because the measure used to define handedness has been incorrect (Prichard, Propper & Christman, 2013).

Lyle, Hanaver-Torrez, Hacklander and Edlin (2011) study established consistency of handedness, regardless of direction, is an important individual difference factor in memory. They compared consistent and inconsistent Left- and Right-Handers on associative recognition tasks taken after saccades and no-saccades control activity. The results indicated consistent-handers displayed poorer memory in comparison to inconsistent-handers following the control activity, and saccades heightened retrieval for consistent-handers only. Saccades impaired retrieval for inconsistent-handers. The effects of this study did not depend on left/right direction, thus establishing that consistency of handedness is an important factor in memory.

Research in to the effects of handedness on memory has accumulated that Strongly Right-Handedness is associated with inferior memory performance than Non-Strongly Right-Handedness (Propper, Christman & Phaneuf, 2005). The superior memory performance in Non-Strongly Right-Handed individuals can be explained by the interhemispheric interaction hypothesis. This explains that the degree of handedness affects the degree of interhemispheric interaction in the brain and that this interaction is related to the enhanced retrieval of memory. The hemispheric interaction theory states that the memory advantage of Non-Strongly Right-Handed subjects is due to greater hemispheric interaction, this is evident from up to date research by Christman, Propper and colleagues. Christman, Propper and colleagues demonstrated that Non-Strongly Right-Handedness is associated with superior performance on specific memory tasks. Non-Strongly Right-Handed subjects were found to recall more words on a random recall test (Propper at al,. Experiment 1, 2005), precisely retrieve autobiographical events (Propper at al., Experiment 2, 2005), recall childhood memories (Christman et al., 2006), and incorrectly recall less of the non-presented words, after revising a list of presented words associative with non-presented words (Deese, 1959; Roedriger & McDermott, 1955). Based on this research no differences have been demonstrated relative to handedness on recognition accuracy for words (Propper & Christman, 2004). To hypothesise, Non-Strongly Right-Handed subjects have a memory advantage in comparison to Strongly Right-Handed subjects in free recall of laboratory or autobiographical events; however this memory advantage is eliminated when using recognition memory or implicit memory. The association between handedness and memory in individual differences is explained by being driven by the variable, hemispheric interaction (Propper, Christman & Phaneuf, 2005). Hemispheric interaction is defined by the transmission of neural signals amongst the left and right cerebral hemispheres via the Corpus Callosum. The Non-Strongly Right-Handed memory advantage is stronger due to the increased interhemispheric interaction. This advantage is grounded on two leading assumptions. The first assumption clarifies that handedness is a behavioural indicator for the degree of hemispheric interaction. This assumption is supported by many studies which have found that some areas within the corpus callosum (which is the gateway for hemispheric interaction), are larger in Non-Strongly Right Handed subjects, which results in the memory advantage (Cowell, Ketesz & Denenberg, 1993; Habib et al., 1991; Witelson, 1985). The second assumption states, the degree of hemispheric interaction has practical consequences for memory. Those subjects with Corpus agenesis, or those who have had cerebral hemispheres moderately or entirely disengaged via surgical section of the corpus callosum or of other hemispheric commissures, will display memory deficits in relation to those will entirely developed commissures. It suggested that this increased interhemispheric interaction will facilitate improved episodic memory retrieval as episodic memory retrieval is a process which is reliant on interhemispheric co-operation (Ranganath, Johnson & D'Espito, 2000)

In light of Propper, Christman and Phaneufs theory (2005), if this is correct, Non-Strongly Right-Handed participants will have a stronger memory advantage due to increased interhemispheric interaction, which will be observed on tasks requiring retrieval of episodic memory, as retrieval of episodic memory is a process which is reliant on interhemispheric interaction.

Though preceding memory research has shown a memory advantage for Non-Strongly Right-Handed subjects due to having a developed corpus callosum, current research has also shown a superior memory advantage in episodic memory for Mixed-Handed subjects. Experiments were conducted under conditions of both incidental and intentional learning in order to test the generality of a Mixed-Handed advantage in episodic memory (Christman & Butler, 2011). Present experiments demonstrate that a Mixed-Handed advantage arises at the encoding versus retrieval stages, due to Mixed-Handers having inordinate access to the right hemisphere based retrieval mechanisms. These differences may be a result of mixed handedness being associated with superior encoding. Under the condition of intentional learning, Mixed-Handers engage in deeper levels of processing, leading to their advantage in observed memory, however under the condition of incidental learning this advantage may be eliminated due to Mixed-Handers not engaging in deeper levels of processing giving a Strongly Right-Handed memory advantage. However, if a Mixed-Handed advantage is based on the grounds of superior retrieval processes, this advantage should extend within conditions of incidental learning (Christman & Butler, 2011). There is also evidence linking Mixed-Handedness to a higher capacity episodic buffer in working memory (Kemp, Brooks & Christman, 2009). Christman and Butlers research was based on two experiments; Experiment 1, was grounded on the levels of processing effect, proposed by Craik and Tulving (1975), where intentional and incidental learning were compared under the conditions of shallow versus deep processing. Experiment 2 was grounded on a theory proposed by Bucker, Wheeler and Sheridan (2001), in which participants were firstly given a standard memory recognition test, followed by being tested for their incidental memory for distracter items from the initial recognition test. Experiments indicated a Mixed-Handed advantage under both conditions (incidental versus intentional), however only if incidental learning takes place when deeper level of processing are present. These findings were interpreted in two ways; (i) Mixed-Handers engage in greater semantic elaboration at the encoding stage authorising superior retrieval later on, (ii) both Mixed-Handed and Strongly Right-Handed subjects engage in the same semantic elaboration, however Mixed-Handers have superior access to those elaborations (Bucker, Wheeler & Sheridan, 2001).

Other research has shown that there are differences in each of the two cerebral hemispheres in relation to semantic processing capacities (Abernethy & Coney, 1990, 1993, 1996; Beeman & Chiarello, 1998; Chiarello, 1985; Chiarello & Richards, 1992; Chiarello, Burgess, Richards & Pollock, 1990, 1993; Koivisto, 1997, 1998; Koivisto & Lane, 2000; Koivisto & Revonsuo, 2000). The visual half-field paradigm is primarily used to identify the precise role of each cerebral hemisphere in priming. Various researchers considered that the left hemisphere provides more automatic word processing in comparison to the right (Koivisto, 1998; Koivisto & Laine, 2000). Other researchers have criticised that the hemispheric differences be contingent on the extensiveness of semantic activation. The accessibility to word meaning was more diffuse in the right hemisphere (Beeman & Chiarello, 1998). To investigate the hemispheric word differences in timing of word priming, the variation of event related capacities by semantic word relationships was studied in each hemisphere. Significant reaction time and physiological differences in both visual fields were revealed, only for associatively related word pairs. ERP word forms exhibited a dissimilar time-course of associative priming effects according to the visual field it was presented in. In the right visual field/left hemisphere, both N400 effect and late positive component were controlled by semantic affinity, however only a late effect was existent in the left visual field/right hemisphere (Bouaffre & Faita-Ainseba, 2006). The N400 'priming effect' indicates indexes simple Lexical activation, and is modulated by automatic and controlled processes, and has differential influences depending on task requirement (Kutas & Fredermeier, 2000). The contrast between visual fields indicated differences reliant on the semantic link between words. The left hemisphere selectively activates associated words, whereas the right hemisphere performs categorically related word processing (Beeman & Chiarello, 1998). Thus the right cerebral hemisphere is able to activate semantically related words faster than the left hemisphere, this gives evidence in relation to handedness to why those that are Mixed-Handed are able to recall more words than those who are Strongly Right-Handed, due to semantically related words being processed faster in the right cerebral hemisphere, and deeper levels of processing being used (Craik & Tulving, 1975).

Studies regarding the effects of bilateral saccadic eye movements on the retrieval of episodic memories, demonstrate that the performance of Strongly Right-Handed subjects catches up with the performance of Mixed-Handed subjects when engaging in eye movements proximately prior to recall (Christman et al., 2004, 2006). Thus if handedness effects arose at encoding then the manipulation of eye movements would have no effect on performance. In a corresponding manner, tasks that require deeper levels of processing and place high demands on memory retrieval process, elicit more eye movements than tasks with lower retrieval demands (Ehrlichman, Micic, Sousa and Zhu, 2007). However it's not noted whether eye movements are the cause of improved retrieval or if retrieval processes are the cause of eye movements. Eye movements are hypothesized to modulate interhemispheric interaction via bilateral activation of the frontal lobes. This assumption is supported by electrophysiological evidence (Propper, Pierce, Bellarado, Geisler and Christman, 2007). Previous research by Buckner et al. (2001) demonstrated that deeper levels of processing were associated with increased activity in the ventrolateral prefrontal cortex, which has connectivity to the frontal eye fields. This provides converging evidence for an important frontal lobe based interhemispheric component to episodic memory under conditions of elaborative learning and deep levels of processing. Under the condition of elaborative encoding, bilateral saccadic eye movement may be observed due to the connectivity of the frontal eye fields to episodic memory, thus could be an important observation when assessing the extent to which eye movements could improve retrieval.

The proposed study will be an experiment to assess the effects of handedness and its relationship to the retrieval of face-memory, under the conditions of elaborative and non-elaborative learning. Previous research has demonstrated that the effects of handedness are found under conditions of (i) associative learning and retrieval and (ii) elaborative encoding. When using stimuli that demand or require associative processing (in this experiment, face-name pairs) under the conditions of elaborative (vs. non-elaborative) encoding, will assess the extent to which the mixed handed advantage extends to superior retrieval. It is hypothesised that if Propper, Christman and Phaneufs (2005) theory is correct, this superior mixed handed memory advantage will be the result of the reliance on interhemispheric interaction, when retrieving episodic memory.

To hypothesise, significant Mixed-Handed memory advantage will arise on recall under the conditions of elaborative learning, due to Mixed-Handed participants having access to both hemispheres of the brain, and recall under the conditions of non-elaborative learning will be similar for both handedness groups (Strongly Right-Handed vs Mixed-Handed).

If enhanced retrieval is present under the elaborative condition, this enhanced performance should be present in both handedness groups, and should not be specific to the Mixed-Handed group. The extent to which using visual aids (face stimuli) will influence the retrieval of episodic memory under non-elaborative conditions will also be assessed. Shallow levels of processing are demanded when encoding visual stimuli, thus a Mixed-Handed and Strongly Right-Handed memory advantage on the recall on non-elaborative tasks will be similar.

To test these hypotheses, it is proposed that participants be divided across two handedness groups, (Strongly Right-Handed vs Mixed-Handed). After completing the Edinburgh Handedness inventory, they would then be assessed on two recognition tasks. Task 1 would require the participant to engage in varying levels of semantic processing, with 12 stimuli demanding deeper levels of semantic processing and 12 stimuli demanding shallow levels of semantic processing.

Tasks involving the use of elaborative stimuli demand deeper levels of semantic processing thus results in more accurate recall. Tasks involving the use of non-elaborative stimuli demand shallow levels of processing thus result in less accurate recall. The assessments selected for use in this study were created by the researcher, involving two Microsoft Power Point presentations. Two recognition tasks would be produced: Task 1 includes 12 elaborative stimuli and 12 non-elaborative stimuli, this is the encoding stage. Task 2 includes 48 stimuli, 24 which would be included in task one alongside 24 new randomised stimuli, and this is the retrieval stage. The retrieval stage requires the participant to access their semantic memory stores

Methodology

Participants

Participants for this study consisted of 42 adults aged 18 to 60. The sample consisted of 18 Strongly Right-Handed individuals and 24 Mixed-Handed individuals, who were mainly students of the current students of the Manchester Metropolitan University and the remainder were friends or family of the researcher who volunteered to participate. The participants selected from the Manchester Metropolitan University were randomly selected, there was no entrance criteria, participants solely were required to be between the ages of 18 to 60, this criteria also simultaneously applied to the remainder of family or friends of the researcher.

Participants were allocated to one of the two between subjects handedness groups (Strongly Right-Handed versus Mixed-Handed) after completing the Edinburgh Handedness inventory (Oldfield, 1971).

Design

A 2x2 experimental design was used with the between subjects variable being the handedness group that the participants were assigned to which were one of two: Strongly Right-Handed group, Mixed-Handed group. The experiment was conducted used a repeated measures design. After participants were assigned to one of the two between subjects handedness groups they engaged in two recognition tasks. Task 1 was the encoding stage in which participants engaged in non-elaborative and elaborative encoding. They were asked to remember a series of 24 face-name pairs: 12 faces were encoded using non-elaborative encoding and the remainder of 12 faces were remembered using elaborative encoding. The independent variable for the experiment was the handedness groups and the dependent variable was retrieval of face memory, as measured by the elaborative and non-elaborative encoding conditions. Task 2 was the retrieval stage. This consisted of a series of 48 faces, which combined the 24 faces presented in the encoding stage and an additional 24 new faces which were not presented in the encoding stage. These faces were randomized and presented alone without the paired names. The dependent variables that were measured are the proportion HITS and the proportion False Alarms. The proportion HITS were the result of correctly identified faces in the retrieval stage, and the proportion False alarms were the result of incorrectly identified faces. As it is hypothesised that elaborative encoding causes an improvement in retrieval of memory due to deeper levels of processing, it is expected that decreases in errors will be observed for the retrieval of elaborative encoded faces.

A mixed ANOVA experimental design will be used to assess the extent to which handedness influences episodic memory for faces and name retrieval. These variables can only be measured by recognition tasks, using associative learning and retrieval. Thus using stimuli that require associative processing under conditions of elaborative and non-elaborative encoding, we can try to assess the extent to which handedness can influence episodic memory. An experimental design is a way in which we can access internal processing without the use of external memory tasks without using extensive brain imaging equipment.

Apparatus & Materials

The materials required for this experiment consisted of two slideshow presentations which were created by the researcher, and participants were also assessed on handedness using a modified version of the Edinburgh Handedness Inventory (Oldfield, 1971; see appendices).

The Edinburgh Handedness Inventory (Oldfield, 1971) is used for the assessment and analysis of handedness. It is a measurement scale used to assess handedness: the dominance of a person's left or right hand in everyday activities. These everyday activities include things such as: 'Which hand do you brush your teeth with?', 'Which hand would you use to open a jar?' The use of this measurement scale can be unreliable due to participants over attributing tasks to the dominant hand. Participants were required to fill in this inventory which consisted of ten items. Permission to use this inventory is not required.

The two recognition tasks were created using the Microsoft Office software called Microsoft Power Point. This software was used to create two Power Point presentations. Task one was created using randomised faces which were retrieved from the internet, and names which are used to match these faces were also randomly selected by the researcher. This same process as applied for task 2, for the retrieval stage. An example of these Microsoft Power Point presentations is appended (See appendix).

Task 1 and task 2 were administrated to the participant using a laptop, and the participant was required to follow the instructions on the Power Point presentations. Task 1 presented 24 slides, and participants were given 10 seconds to remember each slide which was presented to them. The non-elaborative slides contained a sentence along with the face-name pair simply asking the participant to 'remember the slide', and the elaborative slides face-name pair was combined with a sentence which asked 'does this name match this face?'.

Task 2 was again administrated to the participant using a laptop screen, and participants were this time given 5 seconds to answer whether or not they could recall the face from task 1. 'HITS' and 'False Alarms' were scored on a results sheet which again was constructed by the researcher. The results sheet used is appended (see appendix). All scores recorded on the results sheet were calculated into proportion HITS and proportion False Alarms. These scores were later put into IBM SPSS Statistics for analysis.

Procedure

The proposed study will assess the extent to which handedness influences episodic memory for faces and name retrieval.

Participants first read the information and brief sheet and gave verbal and written consent participate in the experiment. They then were given a participant number. Following the brief, participants then completed the Edinburgh Handedness inventory, and provided demographic information which consisted of their age and gender. Participants were then allocated to one of the two between subjects groups: (a) the Strongly Right-Handed group, or (b) the Mixed-Handed group.

This allocation will follow the administration of the Edinburgh Handedness inventory and scoring. This allocation is done as follows: the Edinburgh handedness scale consists of 10 items. Scoring is done by allocating scores for each item on the scale: Minus 10 for a response of 'Always Left', minus 5 for 'Usually Left', 0 for 'No Preference', Plus 5 for 'Usually Right, and plus 10 for 'Always Right'. After the handedness inventory is completed, scores will be added up to allocate participants to each of the handedness groups. Maximum score in total would calculate to be plus 100 (extremely right handed), and minimum possible score would be minus 100 (extremely left handed). Those participants scoring below minus 80 would be considered extremely left handed, and those above plus 80 extremely right handed, those participants in between 80 and minus 80 would be labelled as mixed handed. This scoring is

After the allocation stage, the experiment will be carried out. This procedure was as follows. Participants were asked firstly to sit in front of a laptop screen. In the encoding stage (Task 1), participants were presented with a series of 24 faces: 12 stimuli for the elaborative encoding condition and 12 stimuli in the non-elaborative encoding condition. These stimuli were inter-mixed during the stimuli-presentation stage (encoding stage). These were presented to the participants using a Microsoft PowerPoint presentation. For the elaborative condition the participants are presented with a face plus a noun, this was a name. This faces presented for the elaborative condition will also be combined with a sentence which will say: 'Does this name match this face?' They would then be asked on the second presentation that provides faces only to recall the name or asked how fitting that name was to the face. This sentence will allow for deeper levels of processing, and will aid encoding as associative learning will take place. For the non-elaborative condition the participants are asked simply to remember the pairing of a face and a name. The faces presented for the non-elaborative condition will again also be combined with a sentence which will state: 'Remember this slide'. This does not allow for any deeper levels of processing, but solely to encode what is presented on the slide. An example of each of the elaborative and non-elaborative encoding slides are shown below, these are shown as they would be presented in the initial experiment:

Figure 1 **Non-elaborative encoding slide** **Figure 2** **Elaborative encoding slide**

Participants were given a duration of 10 seconds per slide to encode all information which was presented to them. This 10 seconds was timed using a stopwatch. Adherence to these instructions were stressed to the participants before the slideshow began by the researcher. After task 1 was completed, the researcher explained the instructions for the second task. In Task 2 they were asked by the researcher to express if they had seen the faces presented in the task 2 slideshow, previously in task 1. Task 2 will measure the dependent variable.

The dependent variable was then measured using a second slide presentation which consisted of 48 faces. This included the first 24 faces with an additional 24 faces that were not originally presented at the encoding stage. This is the retrieval stage of the experiment. An example of how the slides were presented on the retrieval stage are shown below, these are shown as they would be presented in the experiment:

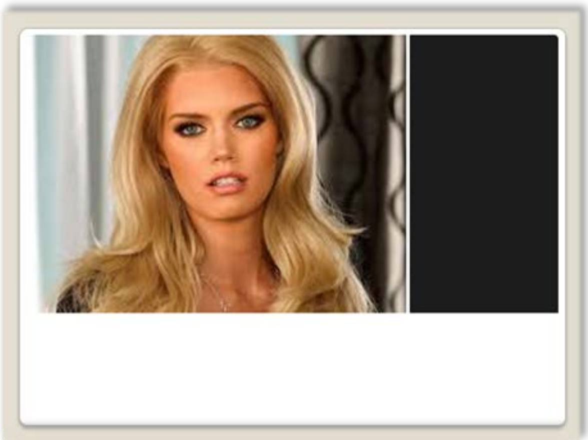


Figure 3 **Retrieval stage slide**

Figure 4 **Retrieval stage slide**

Participants were asked to indicate ‘Do you recognise this face from the first set of faces?’ If the response is ‘yes’ they were then asked ‘What was the name assigned to this face?’ if the answer is no the experimenter would move on to the next photo. This provide: (a) a measure of ‘HITS’, for correctly identified faces, and also (b) a measure of ‘False Alarms’, for incorrectly identified faces. These measures will be used for both of the experimental conditions.

After completion of task 2, participants were debriefed by the experimenter verbally, and participants were also required to read a debrief sheet. On this sheet they created a unique personal code in which their results could be easily removed from the data set, if they later wished to withdraw from the experiment. Participants were thanked for participating in the experiment and reminded of their right to withdraw from the experiment. They were reminded that their data would be kept anonymous, however cautioned that their results may be discussed with the project supervisor.

The data recorded from the measures of the dependent variable will then be used by converting the ‘HITS’ and ‘False Alarms’ into proportion scores. For example, if a participant identifies 8 out of 12 faces in the elaborative encoding condition, this will be scored as 8/12 hits (.6666666 recurring). These proportion scores are converted to Z scores. This same procedure is used for the false alarms. The dependent variable is then measured by subtracting the false alarm z scores from the hit z scores. This is employed in both the elaborative and non-elaborative condition. These results will then be analysed using a 2 x 2 Mixed ANOVA, to assess whether or not mixed handed participants performed better overall than the strongly right handers or whether performance for all participants was better in the 'elaborative' condition. These results will also assess whether or not mixed handers performed better in the 'elaborative' condition, in terms of the hypothesis. It is hypothesized that there will be an increased recall rate and less errors will be made under the elaborative condition for mixed handed subjects as association requires deeper levels of processing and place higher demands on memory retrieval processes, however within the non-elaborative condition recall rates will be similar as shallow levels of processing is required.

Ethics

This study was given ethical approval and was conducted in adherence to the Manchester Metropolitan University Psychology Department Guidelines and the British Psychological Society.

Results

Scores for a test of handedness were obtained on completion of the Edinburgh Handedness Inventory by the participants. The results of handedness inventory allocated participants to one of the two between measures groups: Strongly Right-handed (N = 18), and Mixed-handed (N = 24). A total numbers of (N=42) participants were involved in the experiment.

After the completion of the experiment on a total of 42 participants, recorded scores were calculated into proportion 'HITS' and proportion 'False Alarms'. The proportion 'HIT' scores and proportion 'False Alarm' scores were inputted individually into the software IBM SPSS Statistics for each coding condition (Elaborative and Non-Elaborative), alongside each individuals handedness group (Strongly Right-Handed versus Mixed-Handed).

Using these proportion 'HITS' and proportion 'False Alarms', another two columns were created in the SPSS data set, one for each condition. These columns calculated the proportion of 'HITS' minus the proportion of 'False Alarms'. These were calculated for each of the two groups under each of the repeated measures conditions (Elaborative and Non-Elaborative).

After inputting all the data into the software IBM SPSS Statistics, a 2x2 Mixed ANOVA analysis was carried out.

The scores in **Table 1** represent the total mean and standard deviation of the proportion of 'HITS' minus the proportion of 'False Alarms' for each of the two groups of handedness (Strongly Right-Handed versus Mixed-Handed) under each repeated measure (Elaborative versus Non-Elaborative).

Table 1

Mean and standard deviations for all groups of handedness

	Elaborative		**Non elaborative**	
	M	*SD*	*M*	*SD*
Mixed-Handed	.61	.21	.67	.23
Strongly Right-Handed	.56	.33	.73	.22

The mean difference between the Mixed-Handed participants and the Strongly Right-Handed participants in the Elaborative condition is 0.05 on the Elaborative coding task. In the Non-Elaborative encoding condition, strongly Right-Handed participants out-performed Mixed-Handed participants with a mean difference of 0.06.

Table 2 provides the overall means and standard deviations for both handedness conditions (Mixed-Handed and Strongly Right-Handed) within the two coding conditions (Elaborative and Non-Elaborative). Also included are the descriptive statistics for all Mixed Handed participants (combining the two groups of coding) and all Strongly Right-Handed Participants (combining the two groups of coding).

Table 2

Overall means and standard deviations for handedness

Overall scores in the elaborative condition		**Overall scores in the Non-elaborative condition**		**Overall Mixed Handedness scores**		**Overall Strongly Right-Handedness scores**	
M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
.59	.27	.70	.22	1.28	.44	1.28	.55

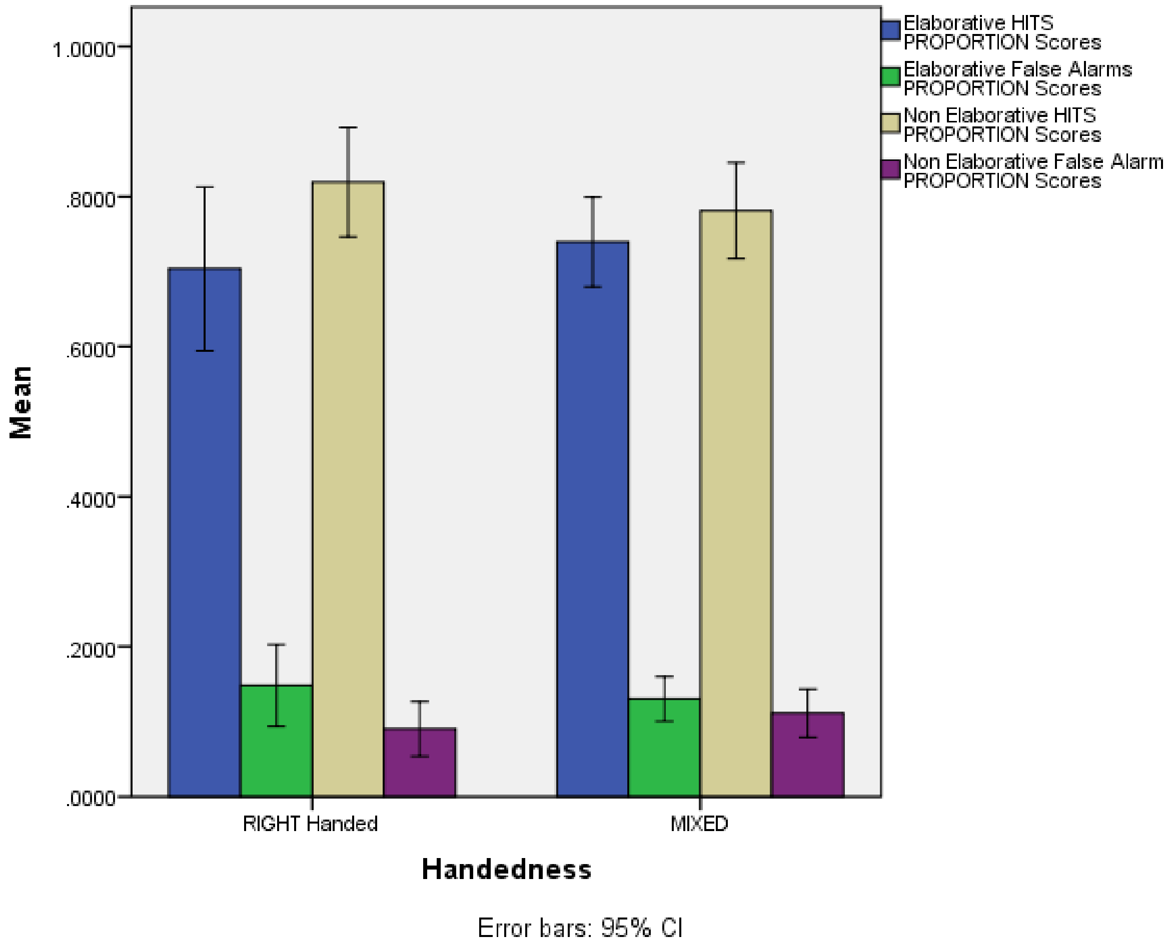
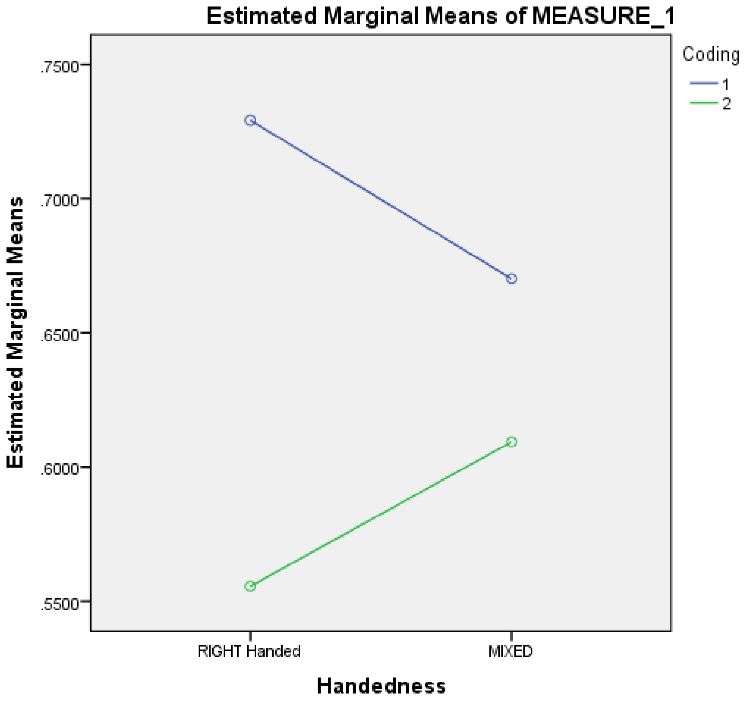


Figure 5: Histogram of proportion scores for Handedness and standard error confidence intervals (95%) for HITS and False alarms in each condition.

The means of the two means for the Right-Handed and Mixed-Handed participants were obtained for the two coding conditions, the overall means for Right-Handed participants (*M* = .64) and for Mixed-Handed participants (*M* = .64); these means explain the insignificant main effect for the relationship for handedness.

A 2 (Handedness: Strongly Right-Handed vs Mixed-Handed) between subjects x 2 (Elaborative vs Non-Elaborative) within subjects Mixed ANOVA was performed on the data and surprisingly both the Mixed-Handed participants and Strongly Right-Handed participants recalled more faces in the non-elaborative coding condition than in the elaborative coding condition. The ANOVA revealed a significant main effect for coding, *F* = 6.08; df = 1, 40; *p* < .02.

The ANOVA revealed an insignificant interaction for 'Handedness'. No significant main effect was observed for 'Handedness', *F* = 0.00; df = 1, 40; *p* > .05. A significant interaction between 'Handedness' and 'Coding' was not found, *F* = 1.41; df = 1, 40; *p* > .05.



1) **Non-Elaborative coding condition**
2) **Elaborative coding condition**

Figure 6: Plots illustrating the interaction between the two variables (Handedness and Coding)

Summary of Main Findings

For the recognition task, no main effect was found for both groups of handedness (Strongly Right-Handed vs Mixed-Handed). The 2x2 Mixed ANOVA revealed that there was no significant difference between recall between the two handedness groups, thus accuracy was not observed for the interaction between the handedness groups on recall. In both groups recall was similar, and recall was not superior in the Mixed-Handed group, thus indicating handedness do not alter the rate of retrieval.

A significant main effect was revealed for the coding conditions, increased recall was revealed for the non-elaborative condition than the elaborative coding condition. This however exposed an unexpected opposite main effect, as it was hypothesised that an increased recall rate in the elaborative condition would be observed. No interaction effect between handedness and coding was found, thus indicating handedness has no effect on the retrieval of episodic memory, whether encoding be elaborative or non-elaborative.

Discussion

In the current study, effects of handedness on retrieval of face-memory, under the conditions of elaborative and non-elaborative encoding was investigated. A 2x2 ANOVA was performed on the data collected from the experiment, using the software IBM SPSS Statistics to run the analysis.

The results from the experiment revealed an insignificant interaction for 'Handedness', thus no main effect for handedness was observed. Also no significant interaction was found between 'Handedness' and 'Coding'. Although no main effects were found for 'Handedness' or 'Handedness and Coding', a significant main effect was revealed for 'Coding' alone. Under the Non-Elaborative coding condition, participants were required to remember a series of 12 slides, which contained a face-name pair and sentences cueing the participant to 'remember the slide'. Participants were given a 10 second duration to remember the slides, the Non-Elaborative stimuli were intermixed with 12 Elaborative stimuli. Participants in both handedness groups (Strongly Right-Handed vs Mixed-Handed) unexpectedly, significantly increased recall of faces in the non-elaborative condition. This revealed an opposite main effect where there was enhanced recall under the Non-Elaborative encoding condition than in the Elaborative encoding condition. These results do not support the hypothesis, as the hypothesis stated that there would be enhanced recall in the Elaborative coding condition, due to deeper levels of semantic processing.

Results from the experiment revealed both handedness groups (Strongly Right-Handed vs Mixed-Handed) recalled more faces in the Non-Elaborative coding condition than in the Elaborative coding condition, these results also do not support the hypothesis, as Mixed-Handed participants were expected to recall more faces under the elaborative coding condition. This hypothesis was based on the interhemispheric interaction theory which states that Mixed-Handed participants outperform Strongly Right-Handed participants in the retrieval of episodic memory, due to increased access and interaction between both hemispheres of the brain and increased access to the semantic memory stores.

Strongly Right-Handedness is associated with poorer memory performance than Non-Strongly Right-Handedness (Propper, Christman &Phaneuf, 2005. The hemispheric interaction theory states that the Non-Strongly Right-Handed advantage occurs due to Non-Strongly Right-Handedness in comparison to Strongly Right-Handedness is a behavioural marker for superior interaction of the two cerebral hemispheres. The hemispheric interaction theory predicted that the Non-Strongly Right-Handed memory advantage should be observed specifically on tasks which require hemispheric interaction. The results to the study contradict the hemispheric interaction theory, as a Non-Strongly Right-Handed memory advantage was not present on the retrieval of faces under the elaborative encoding condition where increased interhemispheric activity should have been present due to deeper levels of processing. Means derived from the analysis of the data revealed enhanced performance of Strongly Right-Handers in the Non-Elaborative condition, revealing a mean of .73 and an enhanced performance for Non-Strongly Right-Handers also in the Non-Elaborative condition, with a mean of .67. However, Strongly-Right Handed participants outperformed Non-Strongly Right-Handed participants with a mean difference of 0.06 under the non-elaborative coding condition. This supports the hypothesis that Strongly Right-Handed participants would outperform Non-Strongly

Right-Handed participants in the non-elaborative condition, and also reveals a significant main effect for coding however in the opposite direction.

Although participants performed better in the Non-elaborative condition between both handedness groups, the mean results for the retrieval of faces under the elaborative condition between both groups were similar to the means for the Non-Elaborative condition. The overall means for the two handedness groups were obtained for the two coding conditions: the overall means for Right-Handed participants (M = .64), and for Mixed-Handed participants (M = .64). These means explain the insignificant main effect for the relationship for handedness.

There are several suggestions on the current results found on the evaluation of handedness and face-memory retrieval, indicating reasons to why significant main effects were not observed for the retrieval of face-memory between the handedness conditions. Faces which were used in the encoding and retrieval stages of this experiment were faces who were not famous, these faces were used so that they did not aid elaborative learning when the participants were encoding the Non-Elaborative stimuli. Randomised non-famous faces were used for both conditions of encoding. Lyle and Orsborn (2011) tested the account that inconsistent handedness and saccade execution are associated with increased hemispheric interaction, which facilitates retrieval.

They carried out a study in which participants classified faces as famous or novel. These faces were presented to the participants in the left and right visual fields bilaterally or unilaterally. The results revealed that participants classified famous faces more quickly and more accurately when the presentation was in both visual fields, however novel faces were not. These effects from bilateral gain indicate that interhemispheric interaction dominantly facilitates famous-face recognition, therefore enhanced classification of famous faces may reflect greater interhemispheric interaction. However results indicated neither inconsistent handedness nor saccade execution increased the size of bilateral gain effects, although these variables did increase face-classification accuracy. Nonetheless, these increases were not explicit to famous-face recognition, but were robust for novel –face identification. Lyle and Orsborn (2011) results indicated the favourable effects of inconsistent handedness and saccade execution to faces, however demonstrated that these effects are not caused by interhemispheric interaction.

The results of Lyle and Orsborns (2011) study indicate that the recognition of novel/randomised faces increase recall accuracy. These results are also evident in this study as specifically randomised faces were presented in the recognition tasks, these faces were not faces of famous people. Participants scores for correctly identified faces were enhanced under both conditions of encoding (Elaborative vs Non-Elaborative), in the retrieval stage of the recognition tasks, regardless of the different levels of processing, these results support Lyle and Orsborns (2011) conclusion that recognition of novel faces increase recall accuracy. This indicates handedness does not have an effect on the retrieval of face-memory, as handedness is reliant on interhemispheric interaction. This supports the insignificant interaction found for ‘Handedness’ and ‘Coding’.

To assess the recall between both groups of handedness (Strongly Right-Handed vs Mixed-Handed) under both conditions of coding, the duration between delivering the encoding task and delivering the retrieval task must be considered. Wheeler and Roediger (1992) emphasised the interval between memory tasks as being the critical factor in the measurement of accurate retrieval of memory. They proposed that the interval between memory tasks should be short, duration of the interval should be a matter of minutes for performance on non-cued tasks to be significantly enhanced. In this study the duration between delivering task 1 and 2 was a matter of a few minutes. The results demonstrated that there was a significant interaction between the two coding conditions (Elaborative versus Non-Elaborative), however a significant was only present in the non-elaborative coding condition, than being present in the non-elaborative condition as it was hypothesised. Participants completed the viewing of the task 1 (the encoding stage) presentation in which they memorised visual stimuli (face-name pairs), and then after approximately 2 minutes they were presented with task 2 (the retrieval stage) presentation, in which they were assessed on retrieval of the faces they were presented with in task 1. The significant increase in recall of the non-elaborative stimuli complies with the results of Rooy et al (2005). Rooy et al (2005) found that hypermnesic effects only occurred when participants are assessed instantly. Hypermnesia refers to the phenomena of an enhanced memory, particularly in terms of recall.

The results of the present study do not support the interhemispheric interaction theory as a significant main effect was not found for handedness, contradicting the idea that increased interhemispheric interaction which Mixed-Handed participants are reliant on will result in superior memory retrieval, as this was not observation was demonstrated in the analysis of the results.

Methodological issues which have arisen are firstly the reliability of the experiment within the given settings. Participants were assessed in a natural setting, thus although they were comfortable, they were under experimental conditions which put them under pressure to try to encode as much stimuli as they could in the given time of 10 seconds per slide. Also encoding is self-regulated, the learner decides which information to encode, how long to focus on each bit of information presented to them in each slide and how to encode it. Participants may have constrained to the demands of the researcher however on the other hand they may have created their own associations for the face-name pair, for example: in the non-elaborative condition, participants were only asked to remember the slide, however to aid themselves to encode what was presented to them they may have created their own elaborative associations. Only in the elaborative coding condition were the participants given the cue for association, as they were asked ‘does this face match the name’.

Secondly in future experiments to test handedness and its relationship to the retrieval of face memory, a distracter task may be beneficial for accurate results between the two face recognition tasks. This will stop hypermneisc effects from occurring, as the presented information is encoded very recently in the participant’s minds. A distracter task may increase the accuracy of retrieval of face memory, as it will assess the extent to how long a person can retain and recognise face stimuli, without having to retrieve it instantly.

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